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Eastern Illinois University

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Efficacy of a Single Session of Static Stretching and Proprioceptive

Nueromuscular Facilitation Stretching on Hip Range of Motion After Exercise

(TITLE)

BY

Hannah J. Vacey

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

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IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
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Efficacy of a Single Session of Static Stretching and Proprioceptive Neuromuscular Facilitation Stretching on Hip Range of Motion after Exercise

ABSTRACT

The purpose of this study was to compare a single bout of stretching; either static stretching (SS) or proprioceptive neuromuscular facilitation (PNF) stretching and no stretching (C) on hip range of motion (ROM) after walking on the treadmill for 30 minutes. Differences among stretching groups, between males and females for all subjects combined at baseline and post-test measurements were also investigated. Thirty-five physically active, non-collegiate athlete volunteers (21 males, 14 females) between the ages of 18-26 were recruited to participate in this study. Descriptive statistics were obtained from each subject as well as exercise history regarding aerobic, resistance and flexibility training frequency and duration. All subjects participated in a five minute treadmill walking warm up, measurement of hip ROM, thirty minutes of walking on the treadmill at a moderate intensity (11-12 on Borg's RPE Scale) (Borg, 1982) followed by a stretching treatment and post-test measurement of hip ROM. The C group did not receive a stretching treatment; the SS group performed four researcher applied passive static stretches held for 30 seconds. The PNF group performed three researcher applied contract-relax stretches with a six second maximal contraction and a passive portion held for 20 seconds.

There were no significant differences among the three groups from baseline ($p = 0.506$) to post-test ($p = 0.397$) measurements of hip ROM. Between stretching groups of males and females there was no significant difference from baseline ($p = 0.180$) to post-test ($p = 0.281$). There was a significant difference between male's hip ROM ($p = 0.001$) from baseline to post-test; female's hip ROM approached significance ($p = 0.052$). For males and females combined for all treatment groups there was a significant increased from baseline to post-test ($p < .05$).

Therefore this investigation concluded that thirty minutes of exercise at a moderate intensity is sufficient to increase hip range of motion in a physically active population of college age men and women but it is unclear which method of stretching is the most effective.

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CHAPTER I

INTRODUCTION

Flexibility is one of the health related components of physical fitness and should be incorporated into programs for both the recreational exerciser with general fitness goals as well as athletes who need to be in top physical shape. Stretching is extremely beneficial for activities of daily living (ADL) throughout life and contributes to improvements and maintenance of range of motion (ROM) and physical function. These factors are particularly important in fighting the loss in ROM associated with aging (Thompson, Gordon, & Pescatello, 2010). Although joint flexibility decreases with aging, flexibility can be improved across all ages and is encouraged in both the active and sedentary populations (American College of Sports Medicine, 2011).

The goal of a flexibility program is to increase joint ROM to its anatomic maximum end point (ACSM, 2011). Regular stretching leads to increased flexibility allowing an individual to move through a greater ROM before being limited by pain and increases efficiency of movement. A flexibility program, as explained by Alter (1996), through relaxation of the the muscles, can lead to decreased pain caused by tense or tight muscles. It can also lead to decreased stress and incidences of low back pain. Increased flexibility can promote better posture which also reduces low back pain. Stretching can reduce muscle cramps, both acutely and chronically, and has been shown to reduce some muscle soreness (Alter, 1996).

Flexibility exercise specifically refers to activities designed to preserve or extend ROM around a joint (ACSM, 2009). Increasing ROM by means of stretching is important to retain flexibility and helps individuals accomplish ADL. These include activities needed to maintain independence, stay mobile and perform self-care. Maintaining flexibility is important for the elderly population and anyone at high risk for falls. The American College of Sports Medicine (ACSM) Position Stand on Exercise and Physical Activity for Older Adults states that multimodal programs of balance, strength, flexibility and walking are shown to reduce the risk of both non-injurious and injurious falls (American College of Sports Medicine, 2009); which is particularly important to the older population. Maintenance of flexibility may also be beneficial as decreased ankle flexibility in older adults is linked with an increased risk of falls due to diminished functional ability and balance (Ehrman et al., 2010).

Poor lower-back and hip flexibility, in conjunction with weak abdominal strength and endurance, may contribute to development of muscular low-back pain. However this hypothesis is debated (Thompson et al., 2010) as there is a negative relationship between increased flexibility and low back pain, as flexibility increases, low back pain is typically less. Flexibility exercises may enhance postural stability and balance (ACSM, 2011) which is important across all age groups.

The ACSM (Thompson et al., 2010) provides specific guidelines for flexibility training programs. There is controversy as to the best time to perform stretching exercises; either before or after aerobic and resistance training activities, whether or not acute stretching before activity enhances or decreases performance and if stretching is associated with injury prevention. The bottom line is stretching after exercise is in most cases, the more effective time to stretch but also seems to be dependent on the individual (Witvrouw, Mahieu, Danneels, & McNair, 2004). There exists several stretches to engage in such as static stretching, proprioceptive neuromuscular facilitation (PNF), dynamic and ballistic stretching. Each mode has a different mechanism for increasing ROM and while the main goal of stretching is identical for all types.

Several studies have investigated different variables of stretching programs to determine the most effective ways of increasing ROM. These variables include the type of stretch performed, the number of repetitions to repeat the stretch and duration to hold each stretch (ACSM, 2011; Bandy & Irion, 1994; Wallin, Ekblom, Grahn, & Nordenborg, 1985). Other studies question the effect of prior exercise on ROM, when to stretch, the impact of stretching on performance, and if stretching is an effective mechanism to reduce injury (Beedle, Leydig, & Carnucci, 2007; Funk, Swank, Mikla, Fagan, & Farr, 2003; Nelson, Kokkonen, & Arnall, 1994; Shrier & Gossal, 2000; Shrier, 2005; Williford, East, Smith, & Burry, 1986).

The hamstring muscles and hip joint appear to be the most commonly studied regions of the body in regards to flexibility and ROM research (Ayala & Andújar, 2010; Funk et al., 2003; Cornelius, Hagemann, & Jackson, 1988; O'Hora, Cartwright, Wade, Hough, & Shum, 2011). Likewise, there are several studies regarding the effectiveness of different stretching protocols, which ones will affect flexibility and ROM the most and the factors that influence these variables (Burke, Culligan, & Holt, 2000 & Funk et al., 2003). What has not been investigated as much is the effect of prior exercise on changes in flexibility.

Purpose of the study

The purpose of this study was to compare a single bout of stretching, either static stretching or proprioceptive neuromuscular facilitation stretching and no stretching on hip ROM after walking on the treadmill for 30 minutes.

Hypothesis

It was hypothesized that there would be a significant difference from baseline to post-test measures of hip ROM after 30 minutes of exercise between experimental groups, static stretch and proprioceptive neuromuscular facilitation stretch, and no stretching. It was also hypothesized that a significant post-exercise difference would exist in baseline and post-test ROM between combined groups of males and combined groups of females. Finally, it was hypothesized that a significant post-exercise difference would exist among all subjects in the study.

Assumptions

Inherent in this study was the assumption that all subjects truthfully reported all exercise histories and opinions during the testing procedure such as perceived work rate and tension of stretch.

Definitions

Compliance --- A measure of the ease with which a structure or substance may be deformed, especially a measure of the ease with which a hollow organ may be distended (Compliance, 2007)

Proprioceptive Neuromuscular Facilitation (PNF) Stretch --- Literally 'promoting or hastening the neuromuscular mechanism through stimulation of the proprioceptors' (Alter, 1996) specifically a muscle group is stretched to its maximum active attainable length and then a maximal contraction is initiated against a stationary object followed by relaxation and a passive static stretch (Burke et al, 2000)

Static Stretch --- Involves moving joint to certain position and holding it in an isometric position. In the case of this study, static stretches were passive (an absence of muscular work) and movement to the isometric position was at a slow velocity (Alter, 1996)

Viscoelasticity --- Refers to the viscous and elastic properties of a muscle; viscosity refers to the property of materials to resist load while elastic properties of the muscle tissue to return to its original size/shape when force is removed (Alter, 1996)

CHAPTER II

REVIEW OF LITERATURE

This literature review is separated into four sections each addressing different components of flexibility and stretching programs. The first section includes literature pertaining to the proposed theories of increasing ROM and muscle length around joints. The second section includes literature regarding the inclusion of a warm up and the impact of prior exercise. Section three; the effect of stretching on performance and the question of injury prevention associated with stretching. Finally, the forth section, literature discussing the current recommendations regarding flexibility training variables.

Increasing Range of Motion and Muscle Length: Proposed Theories

There exist several proposed theories to explain how changes in muscle length and ROM (ROM) occur. One such is that these alterations are a result of the changes in the viscoelastic properties of muscle tendon and connective tissue structures within the body of the muscle itself. "The primary goal of stretching is to alter tendon inflexibility, which contributes to a reduced joint ROM; specifically, elasticity is improved acutely and chronically through stretching" (Ehrman et al., 2010, p. 346). This improvement results in both a transient increase in musculotendon unit length resulting from actin-myosin complex relaxation and chronic alteration of the extracellular matrix (Ehrman et al., 2010). Muscle length increases over time in two ways; (1) if a constant external force is applied allowing the muscle to adapt to the new length or (2) the force with which the muscle fights the external stimuli decreases over time if the muscle is stretched to a constant length and held. When the force is removed the muscle returns to its original length (Shrier & Gossal, 2000). This is essentially the concept behind stretching; moving a joint to a specific point in its ROM and then holding it there until the muscles relax or adapt to the new length at which point the muscle length can be further increased.

Range of motion, which is measured based on angular changes during movement, at a given joint in humans might be primarily limited by pain (Shrier & Gossal, 2000). Therefore the ability to move a joint though a specific ROM without significant impingement or restrictions is its flexibility; increases in flexibility might be a result of an increased stretch tolerance (Shrier & Gossal, 2000). The more a muscle is stretched and allowed to adapt to the new length imposed upon it, the more the stretch tolerance is affected. This concept is essential to increasing ROM because on each subsequent stretch, the joint angle can be increased and over time pain decreases both acutely and chronically while stretch tolerance and flexibility increases. As for the immediate effects, stretching increases ROM through both a decrease in viscoelasticity and an increase in stretch tolerance. With long-term stretching, viscoelasticity remains constant and the increased ROM occurs because more force can be applied to the muscle before the subject feels pain (ie, increased stretch tolerance) (Shrier & Gossal, 2000). These viscoelastic properties vary with different muscle groups.

Other proposed mechanisms for increases in ROM are thought to be either a direct decrease in muscle stiffness via passive viscoelastic changes or an indirect decrease due to reflex inhibition and consequent viscoelasticity changes from decreased actin-myosin cross-bridging. Decreased muscle stiffness, the force required to produce a given change in length, would then allow for increased joint ROM (Shrier & Gossal, 2000) while the reflex inhibition is caused by disinhibiton of muscle spindles. Muscle spindles are responsible for sensing changes in muscle length (Burke etal., 2000), when the signals they send are diminished, the muscle can be stretched further. This decrease in muscle stiffness leads to greater flexibility that the active population strives to achieve for functional activities as well as athletes in their specific sport movements. Activities of daily living as basic as tying one's shoe, bathing, reaching for something on a high shelf and other movements that make independent living possible can be achieved easier with increased flexibility of major muscle groups. As for athletes, varying needs of muscle stiffness exist based on the specific movement requirements of the sport or activity being performed. This topic will be explored in depth later in regards to muscle-tendon unit compliancy needs.

The previous theories hold true for any stretch that includes a static component. Static stretching involves a voluntary passive relaxation of the muscle while it is elongated. This technique involves holding the joint in a static position at the desired muscle length (Ehrman et al., 2010). Static stretching can be active or passive. In passive stretching, a position is assumed while holding a limb or other part of the body with or without the assistance of a partner (ACSM, 2011) an active stretch involves holding the stretched position with the assistance of the strength of the opposing muscles.

Another common stretch is proprioceptive neuromuscular facilitation (PNF). The theoretic basis of PNF stretching is two-fold, first, the isometric contraction of the muscle being stretched stimulates its own Golgi tendon organs (GTOs), resulting in an autogenic inhibition of the stretched muscle which potentially increases the subsequent stretch.

Second, if the opposing muscles are contracted, the result is reciprocal inhibition of the muscle being stretched (Ehrman et al., 2010). Burke and colleagues (2000) attempted to further explain the theories of proprioceptive neuromuscular inhibition in their review of the literature stating that GTOs can override excitatory impulses from the muscle spindles which in turn decreases impulses in an attempt to avoid damage to the muscle-tendon-fascia unit. They concluded that the effectiveness of PNF is possibly a result of several factors; autogenic inhibition, modifications of the muscle spindles, reciprocal innervations or facilitated muscle activations via successive induction and that muscles respond to stretch by viscoelastic properties alone, exclusive of reflex effects (Burke et al., 2000).

During PNF stretching, a muscle group is stretched to its greatest active attainable length and then a maximal contraction is initiated against a stationary object to stimulate muscle activation and is held typically for about six seconds before relaxing the muscle at the new length. The tension created during the isometric contraction causes an adjustment of the muscle spindle sensitivity. Connective tissue then accommodates the stress and maintains the new overall muscle length; these components are believed to respond to viscoelasticity and therefore elongate. For future subsequent stretches, this means the muscle may elongate farther before the reflex responds to stop the muscle from being stretched (Burke et al., 2000).

Conclusion

Based on the current research on the subject, it would seem that increases in ROM and changes in flexibility of major muscles are mainly due to viscoelastic properties. More specifically, these changes result from an increase in stretch tolerance allowing muscles over time to be stretched farther before pain is present and leads to a decrease in muscle stiffness allowing a greater ROM.

Inclusion of a Warm Up & the Effect of Prior Exercise

Flexibility exercises are most effective when the muscle temperature is elevated through light to moderate cardiorespiratory or muscular endurance exercise (ACSM, 2011) and yet a surprising number of studies do not state their subjects participated in a warm up before stretching sessions or before testing procedures (Ayala & Andújar, 2010; Cornelius & Hayes, 1987; Funk et al., 2003; Nelson et al., 2005; O'Hora et al., 2011; & Worrell, Smith, & Winegarder, 1994). The warm up activity affects the muscle in many ways, such as increasing calcium release and coordinating motor unit recruitment patterns, besides simply raising muscle temperature (Shrier & Gossal, 2000). A warm up prepares the body for exercise, which is why dynamic stretching is typically perfomed before activity to prepare the muscles for specific movements. Also, the more a muscle is warmed, the more viscous it becomes, increasing its viscoelasticity (Alter, 1996).

It has been well documented that after the cardiovascular portion of exercise, intramuscular temperature is elevated and more accepting of length changes. Muscle stiffness is decreased, extensibility is increased and therefore post-exercise is thought to be the safest time to perform static stretches, including PNF. Stretching after exercise promotes relaxation of the muscles, improves blood circulation to the joints, helps remove waste products and enhances blood flow to the heart aiding in reduction of a post-exercise hypotensive response (Shreir, 2005). For these physiological reasons, stretching methods including a static component are encouraged as part of the cool down phase of the exercise session.

A study looking at the dynamic ROM of soccer players after both dynamic and static stretching warm ups indicated that dynamic ROM was greater after a dynamic warm up in the front swing phase of a kick vs. a static warm up. This finding is consistent with the principle of specificity and might be beneficial to athletes who want to decrease the likelihood of diminished performance as a result of using a static stretch warm up. Soccer is a very dynamic sport and these athletes could potentially benefit from dynamic stretching performed during their warm up phase of practice (Amiri-Khorasani, Osman, & Yusof, 2011).

The effectiveness of an active warm-up to decrease stiffness appears to be related to the type of warm-up exercise and the muscle group(s) in question (Shrier & Gossal, 2000); again, the principle of specificity. Although activity by itself does not have a major effect on ROM, studies consistently show greater ROM increases after some kind of warm up, either a short preparation or prior exercise itself, followed by stretching than after stretching alone (Ayala & Andújar, 2010; Nelson et al, 2005; O'Hora et al, 2011; Shrier & Gossal, 2000; & Amiri-Khorasani et al, 2011).

There appears to be a need for a greater body of research examining the effect of prior exercise on increasing ROM; few studies have investigated this variable. Funk found that SS and PNF stretching performed before the workout did not increase flexibility. However, PNF stretching after exercise was sufficient for flexibility improvements while SS was not. All subjects had a baseline measurement and then either performed five minutes of stretching or 10 minutes of cycling, upper body conditioning exercises, and an additional 10 minutes of cycling followed by five minutes of stretching. This protocol was repeated with subjects acting as their own controls for both SS and PNF stretches (Funk et al., 2003).

Beedle and colleagues (2007) did a study to determine whether or not static stretching enhanced flexibility when performed before or after an aerobic workout; they hypothesized that post exercise stretching would illicit the greatest increase in flexibility. Tested muscles were the right quadriceps, hamstring, and gastrocnemius; exercise consisted of jogging on a treadmill for 20 minutes. Results indicated that hip flexion, while not significant, was greater for two out of three individuals when stretching occurred after the exercise session. The authors pointed out that when to stretch might be dependent on the individual (Beedle et al., 2007) and the muscles stretched. There also seems to be a positive impact of prior exercise paired with PNF on flexibility and joint ROM. The enhanced flexibility may be due to reduced stiffness of the muscles during subsequent stretching (Nelson et al, 2005). If this is true, PNF stretching is possibly indicated after the endurance portion of exercise due to reduce muscle stiffness and increased muscle compliancy from increased temperature.

A study by Williford and colleagues investigated the effect of a five minute jogging warm up performed before a static stretching protocol, two times a week for nine weeks. The control group did not participate in jogging, only stretching and it was found that static stretching can increase flexibility in the shoulder, hamstring, trunk and ankle. Stretching alone was better for some muscles while jogging before stretching was better for hamstrings, shoulders and ankles. The authors pointed out that warming the muscles prior to stretching was possibly beneficial and that five minutes was long enough to not cause injury due to stretching a 'cold' muscle (Williford et al.,1986). In contrast, a study by Cornelius and colleagues found that no significant difference in ROM at the hip occurred with static stretching before, after, or both before and after a 20-30 minute bout of walking or running (Cornelius et al., 1988).

Conclusion

The general consensus in the research is that stretching should be performed after a warm up. Beyond that, when to stretch to increase flexibility is dependent on the individual, the activity and demands of the activity. It is important to warm up for an activity in a manner most effective for the specific performance requirements.

The Effect of Stretching on Performance and Injuries

Improvements in flexibility can be acute and chronic and are derived from engaging in regular stretching. For some, chronic increases in flexibility are necessary, while for others, acute increases are needed for a specific activity. The issue of when to stretch due to potential decreases in performance has been a controversial subject in many research studies. There seems to be no detrimental effect of stretching after exercise; the major question is the effectiveness before exercise and the possible effect on performance.

If an activated muscle is stretched before shortening, its performance is enhanced during the concentric phase; likewise, muscle tendon units can store mechanical work as elastic energy during eccentric contractions (Witvrouw et al., 2004) such as a vertical jump. A more compliant muscle tendon unit allows for the effective storage and release of series elastic energy but is less suited for activities such as cycling, skating and swimming. More compliant muscles generate less power due to the delayed transfer of energy through the muscle-tendon unit. In contrast, in a less compliant, stiffer muscle-tendon unit the faster the force is transferred to the bones, the faster the movement. Sports requiring fast powerful contractions, such as sprinting, require less compliant muscle-tendon units and sports such as jogging which require a higher frequency of stretch shortening cycles at a low percentage of maximum contraction require a more compliant muscle (Witvrouw et al., 2004). Those who require a more compliant muscle would benefit from stretching before their activity while those who need a less compliant muscle do not need to be concerned with stretching before the activity.

Stretching exercises can have a negative effect on sports performance, particularly when strength and power are important (ACSM, 2011). This need is dependent on the type of activity and movements to be performed. The ACSM states that for sport activities where muscular strength, power, and endurance are important for performance, it is recommended that static stretching be performed following activity rather than during the warm-up period (Thompson et al., 2011). It has been suggested that the possibility of overstretching or just simply stretching muscles makes them less effective and is again dependent on the type of activity being performed and respective compliancy demands.

Nelson and colleagues found a significant and repeatable decrease in knee flexion of "maximal muscle strength endurance performance" (Nelson et al., 2005) following an acute static stretching treatment. Subjects performed prone knee flexion at 60% of body weight two days in a row and three to four months later with 40% of body weight. Subjects either sat quietly for 10 minutes prior to the exercise or performed 15 minutes of static stretching on various leg muscles. They were careful to note that their study suggested that an intense stretching protocol will reduce endurance of "one set to failure" activities involving maximal muscle strength and that there is room for other types of stretching protocols before exercise (Nelson et al., 2005) such as dynamic, continuous movement stretching as part of the warm up. This suggestion was for resistance type exercises and due to the principle of specificity may not carry over to an endurance aerobic activity such as jogging which requires a more compliant muscle-tendon unit (Witvrouw et al., 2004). In contrast, Worrell and colleagues found that open kinetic chain eccentric and concentric peak isokinetic torque values were actually increased after stretching five times a week for three weeks. They noted that this might not carry over to closed kinetic chain activities and more research is needed (Worrell et al., 1994).

Additionally, the ACSM states that for adults exercising for overall physical fitness and athletes performing activities in which flexibility is important, stretching following a warm-up is recommended because of the potential for injury prevention. Also, stretching following the conditioning exercise phase is recommended as a reasonable practice when muscles are warmer (Thompson et al., 2010). For the average recreational exerciser wanting to lead a healthy, active lifestyle there is no need to be concerned with the potential effects on performance that can occur when stretching before exercise (Shreir, 2005). There also appears to be no effect on the likelihood of injury whether one stretches before or after the endurance portion of exercise.

The current research recommends some type of warm up before stretching, regardless of when the stretching session occurs; either before or after the full aerobic exercise session (Shrier & Gossal, 2000). This idea may be interpreted that stretching before exercise prevents injuries, even though the clinical and basic science research suggests otherwise. A more precise interpretation is that warm up prevents injury and stretching has no effect on injury (Shrier & Gossal, 2000). The ACSM states that stretching is widely recommended for injury prevention (Thompson et al., 2010), despite the fact that there is minimal scientific evidence to demonstrate the efficacy in doing so. Also, the ACSM does not specify the best time to stretch for injury prevention. The limited evidence seems to suggest that stretching may be beneficial in preventing injury only in certain types of exercise and there may be little or no benefit in preventing injury during rhythmic, aerobic activities (Thompson et al., 2010). An acute bout of stretching has no effect on decreasing injury risk; however, a regular, chronic stretching routine can lead to decreased injuries over time (Shreir, 2005).

Witvrouw and colleagues (2004) tried to answer the question of the relationship between stretching and injury prevention and primarily found that it depends on the type of exercise or sport activity being performed; the issue of specificity is extremely important to consider (Witvrouw et al., 2004). Therefore, injury prevention would be maximized if athletes and recreational exercisers were aware of the needs of their muscles and could properly place stretching around their activity. Currently it would seem that the best time to stretch is dependent on the sport, dependent on the individual and might not even need to be placed around the exercise session.

Conclusion

Stretching does not seem to be associated with injury prevention except for cases when performance might be affected by muscles being too stiff and not compliant enough for the demands of the activity. There appears to be no detriment on performance when stretching after the activity, but athletes who stretch before activity might experience performance decrease during certain types of activity due to increased muscle compliancy where it is not needed. Also, those who require acute increases in flexibility would benefit from stretching before the activity and those needing chronic increases in flexibility should stretch after the workout or not associated with the workout at all.

Training Variable Recommendations Based on Current Research: Types of Stretches, Frequency, Repetitions and Duration of Stretches

The ACSM (ACSM, 2011) published a position statement in 2010 with the updated recommendations for flexibility program guidelines that the organization's two

Guidelines books reflect (ACSM, 2011; Ehrman et al., 2010; & Thompson et al, 2010). They recommended a variety of stretching types such as static stretching and proprioceptive neuromuscular facilitation stretching due to the different benefits derived from each to increase and maintain flexibility. Additionally, one may participate in dynamic or ballistic stretching. Ballistic stretching is typically not advised for the general population due to the "bouncing" nature of the movement that may activate the stretch reflex which is the opposite goal of stretching. Dynamic stretching is indicated as an active warm up for sports specific movements and those preparing for activity perhaps outside of a typical gym setting. Dynamic stretching mimics the movements of sport activities and involves slow stretching to a certain position with continual movements that do not consist of a static component.

The most common type of stretching is static stretching. This technique has become popular because it is easy to learn, effective and accompanied by minimal incidence of soreness and discomfort. Static stretching is one of the most effective and common techniques to use when comfort and limited training time are major factors in the implementation of a stretching program (Ehrman et al., 2010). Another type of stretching, proprioceptive neuromuscular facilitation, requires a partner trained in administering the technique and therefore may be less practical but has also been shown to increase ROM effectively and may produce slightly larger gains in flexibility of some joints compared with other techniques (ACSM, 2011).

When compared to dynamic or slow movement stretching, PNF and SS produce greater gains in ROM (Funk et al., 2003; & O'Hora et al, 2011). In several studies, stretching protocols have shown statistically significant increases in flexibility and ROM when compared to control groups that received no stretching at all (Bandy & Irion, 1994; Chan, Hong, & Robinson 2001; Fasen et al, 2009; Funk et al., 2003; Nelson et al, 2005; O'Hora et al, 2011, Amiri-Khorasani et al, 2011; & Wallin et al., 1985). In general, differences are found among the effectiveness of stretching protocols as well.

Funk et al., (2003) indicated that the combination of PNF stretching and exercise may be effective in enhancing hamstring flexibility above that observed when compared to the study's other stretching groups. These groups consisted of those who performed static stretching with and without exercise and PNF with and without exercise, each for five minutes. Subjects, all collegiate athletes, acted as their own control and participated in each of the experimental groups in a randomized order. There was no observed difference in the static stretch group but this may be due to the population studied; a greater difference might be found in a less conditioned group (Funk et al., 2003).

O'Hora and colleges examined the effect of a single bout of stretching on increasing ROM using a control group, a static stetching group and a PNF stretch group. They included no warm up and held each stretch for 30 seconds one time. Results indicated that single repetitions of static stretching and PNF are both more effective than no stretch but PNF is more effective than static stretching (O'Hora et al, 2011). Wallin and colleges investigated the effect of ballistic type stretching compared to PNF and found that overall, PNF contract relax method improved flexibility more than ballistic stretching (Wallin et al, 1985). However, in a study by Worrell and colleagues, where subjects performed both SS and PNF five days a week for three weeks, no significant difference in ROM was found between the two stretching protocols. The stretches were performed by the subjects against a table or a chair and some subjects in fact decreased in flexibility as a result of stretching (Worrell et al., 1994).

The ACSM recommends a stretching program of major muscle tendon groups two to three times a week with greater gains observed when flexibility exercises are practiced daily (ACSM, 2011). A study by Wallin and colleagues (1985) found that one session of stretching per week was enough to maintain flexibility once it had been established. Repeating the stretch two to four times is advised (ACSM, 2011) but studies have used repetitions varying from one up to five per muscle stretched (Nelson et al, 2005; O'Hora et al, 2011, & Wallin et al, 1985). However, up to four reps is recommended but may vary in effectiveness for each muscle group beyond four (Shrier & Gossal, 2000). For PNF stretching, it has been shown that three repetitions of a PNF maximum contraction cycle is no more effective than a single maximum contraction (Cornelius & Hayes, 1987). In the book *Facilitated Stretching,* McAtee & Charland (2007) suggested three repetitions of the PNF cycle, where ACSM recommends two to four times (ACSM, 2011). Wallin's subjects repeated PNF stretches five times a session, three times a week either with the contract-relax method (Wallin et al, 1985).

Varying increases in flexibility have been thought to be associated with differing durations of applied tensile force to lengthen the muscle and connective tissue. The longer the force is applied, the more the muscle is lengthened thus increasing flexibility in those muscles and ROM at the respective joint (Shrier & Gossal, 2000). Several studies have investigated different static stretch durations ranging from 15 seconds to 120 seconds (Ayala & Andújar, 2010; Bandy & Irion, 1994; Beedle et al, 2007; Nelson et al, 2005; & O'Hora et al, 2011). Ayala and Andújar (2010) performed a study with groups holding static stretches for 15, 30, and 45 seconds and a control group receiving no stretching for three days a week for 12 weeks. Significant increases were found in all stretching groups from baseline to post-test. However, there were no significant differences in durations of the stretches; 15 seconds was just as effective as 45 seconds and all were more effective than not stretching (Ayala & Andújar, 2010).

The ACSM's 2010 Position Stand states "holding a stretch for 10-30 seconds at the point of tightness or slight discomfort enhances joint ROM, with little apparent benefit resulting from longer durations" (ACSM, 2010). The goal of stretching each muscle group is 60 seconds total which can be split into 30 seconds held twice or 15 seconds held four times (ACSM, 2011). A study performed by Bandy & Irion (1994) examined holding a stretch for 15, 30 and 60 seconds. Subjects stretched the hamstring muscles five times a week for six weeks. They found that 15 seconds was just as effective as no stretching and that holding a stretch for that period of time is essentially ineffective. The results of their study showed that 30 seconds or more was an effective stretch time (Bandy & Irion, 1994). For PNF timing, in a study by Cornelius and Hayes (1987), maximal contractions were held for six seconds, while McAtee & Charland (2007) also instructed the use of a six second maximal contraction. Wallin and colleagues incorporated a seven to eight second maximal isometric contraction followed by two to five seconds of relaxation ending with a passive stretch for another seven to eight seconds (Wallin et al, 1985).

Conclusion

Based on the research it has been concluded that SS and PNF are stretches that are most commonly investigated due to the great degree of ROM gained from them. A stretching routine of two to three times per week of all major muscle groups is recommended and once flexibility has been improved one session a week is sufficient for maintenance. Stretches should be repeated two to three times with SS being held for 30 seconds each and PNF cycles consisting of three to six second maximal contractions with a 20-30 second passive period.

CHAPTER III

METHODS

The purpose of this study was to compare a single bout of stretching, either static stretching or proprioceptive neuromuscular facilitation stretching and no stretching on hip ROM after walking on the treadmill for 30 minutes.

Subjects

Thirty-five collegiate men and women, age 18-26 years, who were physically active on a regular basis but were not collegiate athletes served as subjects for this study. Physically active was defined as those who were not completely sedentary but participated in a minimum of 90 minutes a week as self-reported on an exercise history questionnaire (Appendix A). Subjects were not required to be involved in a structured resistance training or flexibility program to be considered for the study. Exclusion criteria consisted of recent injury with current pain that limited exercise; specifically low back, hamstring, quadriceps or lower leg injuries.

Subjects were told to refrain from heavy lower body resistance training or cardiovascular activity for at least 48 hours prior to their testing time, to prevent possible soreness or tightness associated with these activities from limiting ROM. Subjects completed testing in a single one hour session. Subjects were instructed to eat at some point before testing and were asked if they were experiencing muscle soreness, stiffness or pain at the time of the test. If subjects reported soreness due to prior exercise or extreme muscle tightness they were asked to reschedule.

Personal information including age, height, weight, exercise history/current program of aerobic, resistance and flexibility training was recorded for each subject on a self-reported data sheet (Appendix A). Height was recorded to the nearest 0.5 of an inch on a Seca stadiometer fixed to the wall; weight to the nearest 1.0 pound on a Health O Meter Scale. Both height and weight were measured on the same devices for all subjects with the subject's shoes off. Subjects wore loose fitting, light, workout attire. Subjects gave their voluntary informed consent to participate in this study (Appendix B). The written informed consent was approved by the Institutional Review Board for Human Subjects at Eastern Illinois University.

Protocol

Subjects were randomly assigned to either the control (C) group (n=11), static stretch (SS) group (n=12) or proprioceptive neuromuscular facilitation (PNF) group (n=12). The control group did not participate in any stretching. Before testing began, each subject was asked to kick a ball against a wall five times to determine the dominant leg for testing hip ROM.

All subjects then began with a warm up consisting of walking on a treadmill at 2.5 miles per hour at 0% grade for 5 minutes. After which, a baseline measurement was taken of hip ROM with the dominant leg passively raised to the point of "mild tightness without discomfort" (Thompson et al., 2010, p. 174). A Leighton Flexometer (Spokane, Washington) was used to determine the degrees of flexion. The measurement procedure was adapted from The Leighton Flexometer and Flexibility Test (Leighton, 1966). The Flexometer was placed on the lateral side of the dominant leg on the distal portion of the femur superior to the knee in alignment with the lateral epicondyle. The measurement started with the hip at a 180 degree angle with the subject resting both legs on a table. The knee was kept at 180 degrees of extension throughout testing. The first scale on the Flexometer was zeroed with the knee in this position while the other scale was allowed to move freely with gravity. The hip was then slowly flexed to a point of reported "mild tension without pain" at which point the second scale was locked in place. This procedure was repeated three times and the average value (Ehrman et al., 2010, p. 344), rounded to the nearest half degree, and was recorded for both baseline and post-test measurements. If there was an outlier of more than 10 degrees a fourth measurement was obtained; the outlier was not used in the average.

After the baseline measurement, all subjects walked on the treadmill for 30 minutes at a moderate intensity or what they considered to be 11-12 on Borg's Rating of Perceived Exertion (RPE) Scale at a 5% grade. The ACSM recommends 30 minutes of moderate intensity aerobic activity on most days of the week (Thompson, Gordon, & Pescatello, 2010); therefore, this duration was chosen as an appropriate duration of treadmill walking. Rating of Perceived Exertion is a common assessment tool used to measure intensity due to the strong correlation to heart rate and exercise intensity (Borg, 1982). Subjects were instructed in the use of the Borg 6-20 scale during the warm up session. During the first few minutes of the exercise session RPE was assessed to set a walking speed. Subject's RPE was reassessed at ten and 20 minutes of exercise to ensure subjects were walking at the appropriate intensity (Borg, 1982). If subjects reported an RPE above or below 11-12, speed was adjusted accordingly. If subjects split their time between two speeds, an average speed was calculated and recorded.

After exercise, all subjects waited quietly while lying down on a table for one minute before the stretching treatment was administered. Then, all groups waited an additional minute before post-test measurement of hip ROM. Post-test hip flexion measurements were taken in the same fashion as the baseline measurement. Subjects were not informed of their flexibility scores until after the post-test measurement.

The control group received no stretching treatment and waited quietly for one minute before post-test measurements. The SS group was passively stretched with a straight leg to a point of "mild tightness without discomfort" or the point immediately before the knee needed to bend to compensate for the stretch. The foot was kept in anatomical position by the researcher throughout and the stretch was held for 30 seconds (ACSM, 2011). The researcher ensured that the knee did not bend while an assistant helped to stabilize the hips flat on the table. The leg was then allowed to rest for fifteen seconds and the stretch was repeated a total of four times (ACSM, 2011).

The PNF group was then passively stretched with a straight leg to a point of "mild tightness without discomfort" or the point immediately before the knee needs to bend to compensate for the stretch. The foot was kept in anatomical position by the researcher throughout the stretch. The researcher ensured that the knee did not bend while an assistant helped to stabilize the hips flat on the table. This position was held for 20 seconds, after which the subject performed a maximal isometric contraction of the hamstring for six seconds with resistance provided by the researcher (ACSM, 2011).

This contract-relax method was adapted from McAtee & Charland (2007). The leg was then passively stretched to the reported appropriate tension and the contract-relax procedure was repeated for a total of three stretches (ACSM, 2011). Figure 1 demonstrates the testing protocol.

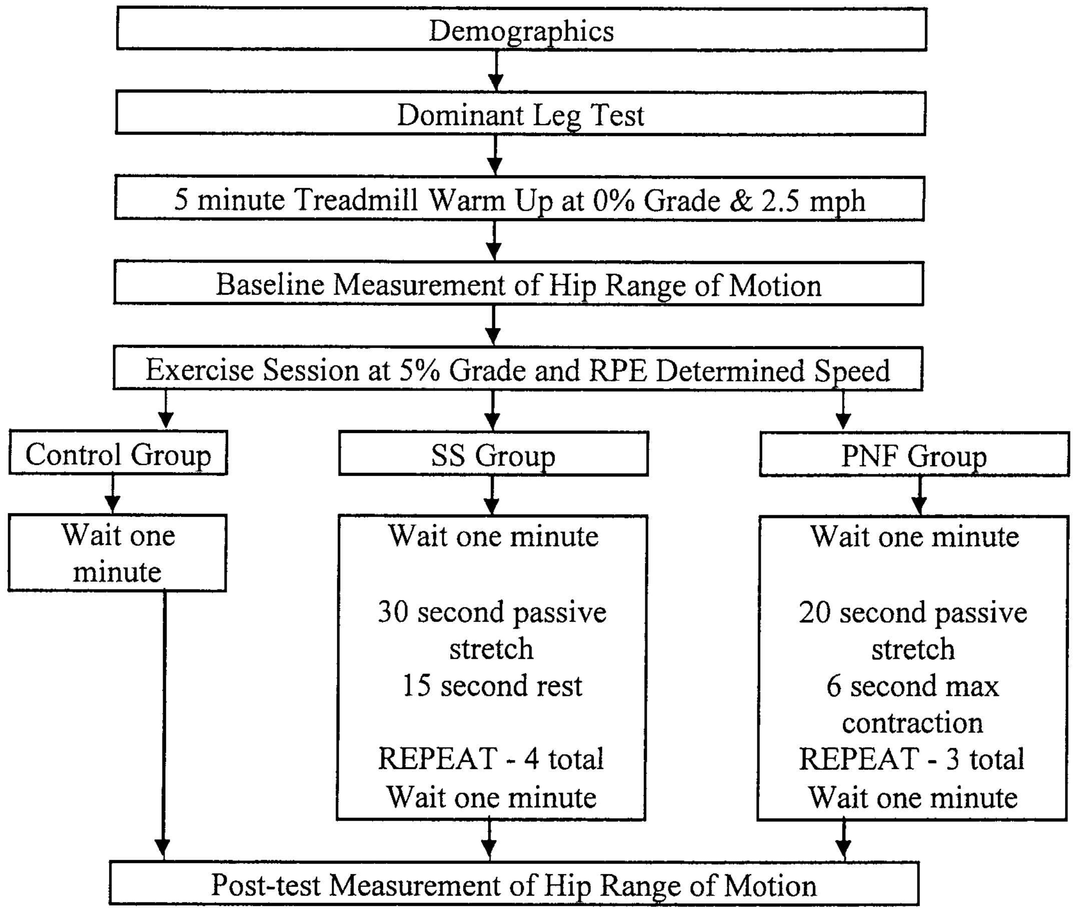

Figure 1. Outline of testing protocol.

Data Analysis

Descriptive statistics (mean ± SD) for all variables were calculated. A one-way ANOVA was conducted to compare baseline and post-test ROM scores to assess significant differences among the three groups (C, SS, and PNF). A two-tailed paired t-test was conducted to compare baseline versus post-test flexibility scores for all subjects pooled together. A one-way ANOVA comparing males and females among groups was also conducted. Paired t-tests determined differences between baseline and post-test measures for males and females separately.

CHAPTER IV

RESULTS

The purpose of this study was to compare a single bout of stretching, either static stretching or proprioceptive neuromuscular facilitation stretching and no stretching on hip ROM after walking on the treadmill for 30 minutes.

Thirty-five collegiate men (n = 21) and women (n = 14) completed this study. Descriptive statistics (mean ± SD) for subject characteristics are presented in Table 1 below.

Table 1. Descriptive statistics for subject demographics.

	Control (n = 11)	PNF (n = 12)	SS (n = 12)	Total (n = 35)
Age (yrs)	22.18 (±2.09)	21.42 (±1.38)	21.75 (±2.09)	21.77 (±1.85)
Height (in)	67.50 (±4.31)	69.75 (±3.45)	68.08 (±3.31)	68.47 (±3.71)
Weight (lbs)	167.95 (±37.70)	163.25 (±29.29)	163.75 (±33.47)	164.9 (±32.59)
Males	7	7	7	21
Females	4	5	5	14

Subjects were required to report being physically active; exercise trends for frequency and duration of aerobic, resistance and flexibility training are presented below in Table 2 and Tables 3. None of the subjects reported being completely sedentary and 26 of 35 (74%) had previously incorporated stretching into their weekly exercise routines.

Table 2. Frequency of aerobic, resistance and flexibility training.

	Aerobic Training	Resistance Training	Flexibility Training
Never	0	3	6
0-1 days/week	1	4	13
2-3 days/week	17	15	13
4-7 days/week	17	13	3

Table 3. Duration of aerobic training.

	Aerobic Training
Never	0
10-30 minutes/session	7
30-60 minutes/session	20
60-90 minutes/session	8

All subjects were randomly assigned to either a static stretching group (SS), a proprioceptive neuromuscular facilitation stretching group (PNF) or a control group (C). Following random assignment, the groups were not significantly different in terms of weight ($p = 0.0935$) or height ($p = 0.325$). Two male subjects, one in the SS group and one from the C, demonstrated left leg dominance. Average walking speed during the exercise session was 2.64 (±0.011) mph at an average reported RPE of 11.40 (±0.50). Walking speed ($p = 0.522$) and RPE ($p = 0.150$) were not statistically significant between groups.

It was hypothesized that a significant difference would exist from baseline to the post-test between SS, PNF and SS groups. An ANOVA indicated no significant difference in hip ROM among the experimental groups and the control at baseline (p = 0.506) or post-test (p = 0.397). The control group had the lowest mean hip ROM at baseline and demonstrated a 3.86 degree increase for the post-test; the PNF group had the highest mean hip ROM at baseline. The mean increase in hip ROM for the PNF and SS groups were 4.88 and 5.00 degrees, respectively (Table 4).

Table 4. Baseline, post-test and change in degrees of hip ROM.

	Control	PNF	SS	Total
Baseline	78.45 (±17.84)	85.75 (±15.96)	84.50 (±13.32)	83.03 (±15.60)
Post-Test	82.32 (±16.32)	90.63 (±15.98)	89.50 (±14.35)	87.63 (±15.53)
Change	3.86 (±4.54)	4.88 (±4.76)	5.00 (±8.76)	4.60 (±6.21)

The male versus female comparisons for all stretching protocol groups from baseline to the post-test are reported in Table 5. Analysis of Variance indicated no significant difference between males and females for hip ROM at baseline (p = 0.180) or the post-test (p = 0.281). A paired t-test indicated a significant increased for males (p = 0.001) for control and experimental groups combined from baseline to post-test; while females approached significance (p = 0.052). Females at baseline had a greater hip ROM.

Table 5. Male vs. female comparisons of baseline and post-test ROM.

	Male	Female	Total
Baseline	80.12 (±11.11)	87.39 (±14.26)	83.03 (±15.60)
Post-Test	85.29 (±16.81)	91.14 (±13.18)	87.63 (±15.53)
Change	5.20 (±6.06)	3.80 (±6.55)	4.60 (±6.23)

A paired t-test indicated there was a significant difference ($p < 0.05$) when comparing groups (C, SS, and PNF) for both male and females from baseline to the post-test hip ROM measurements. Among all groups there was an increase of 4.60 (±6.21) degrees in hip ROM from baseline to the post-test (Table 5).

CHAPTER V

DISCUSSION

The purpose of this study was to compare a single bout of stretching, either static stretching or proprioceptive neuromuscular facilitation stretching and no stretching on hip ROM after walking on the treadmill for 30 minutes.

It was hypothesized that there would be a significant difference from baseline to post-test measures of hip ROM between SS, PNF and C groups. While there was a mean increase in ROM for all groups, no statistically significant difference existed between groups at baseline ($p = 0.506$) and post-test ($p = 0.397$). This finding is inconsistent with other studies.

Beedle and colleagues (2007) found that stretching after a workout was no more effective than stretching before a workout. Subjects performed static stretches after a five minute jogging warm up at 50% max heart rate (MHR) or after 20 minutes, serving as exercise, on the treadmill at 60-80% of their MHR dependent on their fitness level. Similarly, in the current study, subjects performed a five minute warm up before baseline measurements were taken, with an exercise session lasting 30 minutes.

Beedle's subjects stretched three groups of muscles involved in walking and jogging, the quadriceps, hamstrings and calf muscles for 15 seconds, three times with a 10 second rest between repetitions. It was unclear if both legs were stretched; the right side was tested for all ROM measures. Hip ROM measurements were obtained with the knee at 90°while in the current study the knee was kept at 180° therefore values might have differed if a 90° bend was included. Beedle (2007) found that there was no difference in hip ROM whether stretching occurred before or after exercise although hip ROM from stretching after exercise approached significance. Stretching a muscle that is not warmed up is not recommended (Thompson et al., 2010); five to ten minutes of a warm up is suggested. In the case of Beedle's study as well as the current study, inclusion of a warm up might have affected ROM values perhaps causing an increase that was unaccounted for.

Beedle (2007) pointed out that after exercise, muscles and tissues should be more pliable and that 20 minutes should have been a sufficient time to illicit these changes. In the current study subjects performed 30 minutes of activity of a similar intensity found it to be a significant length of time to increase ROM. Also, the researchers only gave their subjects the instructions to "do his or her best" (Beedle et al., 2007) while the current study gave specific instructions, "mild tightness without discomfort", to each participant of the definition of appropriate tension during stretching.

Funk et al. (2003) examined the impact of prior exercise on SS and PNF for a variety of in-season collegiate athletes. Subjects acted as their own controls and performed five minutes of either SS or PNF before or after exercise. The hamstrings were the only muscles stretched for both SS and PNF with the hip in flexion and the knee in full extension. Hip ROM was assessed with the hip at 90°, extending the knee as far as possible. Differing from several studies, the PNF maximal isometric contraction was maintained for 30 seconds, this might have had an impact on the results. Thirty seconds is an extended time to hold a maximal contraction; other studies utilized a much shorter time, six to eight seconds (ACSM, 2011, Cornelius & Hayes, 1987, McAtee & Charland, 2007, & Wallin et al, 1985). However, results indicated that PNF stretching improved hamstring flexibility significantly more when performed after exercise with no significant difference existing between SS and PNF either before or after exercise. Based on the study by Funk and colleagues (2003) both post-exercise SS and PNF stretching are effective means of improving flexibility. The athletic population tested may have contributed to a lack of significant findings with the SS; they might need a more aggressive protocol.

Both Funk (et al., 2003) and the current study examined single session stretching protocols. Subjects in the current study performed stretches in a single session, a protocol that closely follows a study performed by O'Hora et al. (2011). Subjects received no warm up or exercise component neither was there an indication of the current fitness levels in the apparently healthy subjects. Stretches were therapist-applied and included a control group that rested for 30 seconds receiving no stretches, SS consisting of a single 30 second stretch and a PNF stretch with a six second isometric contraction. Baseline and post-test measurements were taken before and after stretching or rest. The hip was kept at 90° of flexion with the degree of knee extension as the ROM determinant of hamstring length during testing and measurements.

It was found that both stretching protocols were significantly more effective than the control group and that PNF stretching significantly increased hamstring length more when compared to SS. This is inconsistent with the current study. If O'Hora (2011) included a warm up there may have been a diminished response and perhaps less significance between protocols and control.

Williford and colleagues (1986) investigated the effect of a five minute jogging warm up on the flexibility of the shoulder, trunk, hamstring and ankle. Subjects jogged and then stretched, stretched without jogging or were in a control group that stretched for 15 minutes twice a week for nine weeks. Stretches were held for 30 seconds each two times, until a point of tightness without pain, bilaterally for the shoulder, trunk, hamstrings and ankle. The jogging group experienced significant gains for all joints except the trunk when compared to the stretch only and C group. This is suggestive that a short warm up has a significant effect on changes in ROM. Results also indicated that "increases in flexibility can occur as a result of a static stretch training program" and that even without a warm up slow static stretching still showed significant increases in flexibility (Williford et al., 1986). Both methods of stretching were more effective that no stretching which is in contrast to the current study.

Worrell et al. (1994) found no significant difference between PNF and SS protocols even though there was an increase in flexibility after stretching four times, five days a week for three weeks. The stretches were self-administered with an anterior pelvic tilt from a standing position against a chair or table. There was no control group and no warm up or exercise portion to this study. Flexibility was assessed via active knee extension and it was concluded that although not significant, both methods were effective at increasing hamstring flexibility.

The second hypothesis for this study predicted a significant difference between male and female hip ROM when groups were combined. The results indicated no significant difference between male and female hip ROM measurements at baseline ($p = 0.180$) and post-test ($p = 0.281$). From baseline to post-test males ($p = 0.001$) experienced a significant mean increase in ROM while females approached significance ($p = 0.052$). This finding is unexpected due to the anatomic difference between males and females at the hip and pelvic girdle; females typically have a greater ROM than men (Alter, 1996). There were no studies found regarding gender differences in flexibility as a result of exercise or stretching protocols beyond anatomical differences.

The third hypothesis predicted a significant difference between baseline and post-test ROM for all both males and females for all variables combined. The present study found a significant ($p < 0.05$) difference between baseline and post-test hip ROM measurements for all groups combined and was the only significant finding. The aforementioned studies all experienced some degree of increase in ROM or flexibility from baseline to post-test measurements regardless of protocol (Beedle et al., 2007; Funk et al., 2003; O'Hora et al., 2011; Williford et al., 1986; Worrell et al., 1994). It is important to note that the control group, who rested quietly after exercise waiting for post-test measurements, also experienced an increase in ROM. Again, while not significant this might indicate that exercise and warming the muscles does have a positive impact on increasing ROM.

There was an average increase of 4.60 (± 6.23) degrees in ROM for all subjects. The greatest increases occurred in the SS group with the greatest individual increase of 21° occurring in a female subject. Not all of the subjects increased in flexibility, some subjects decreased in ROM from baseline to post-test; three females and four men, ranging from a decrease of one to six degrees. Surprisingly, four out of six of these decreases also occurred in the SS group, two females and two males. Whether or not this was a result of the exercise session or stretching protocols is unknown and it cannot be explained why some increased and some decreased in hip ROM or why most of these decreases occurred in the SS group.

Worrell et al (1994) also had subjects that experienced a decrease in ROM from baseline to post-test. They offered no explanation for this difference. They also found that those who started with lower initial flexibility tended to gain more as a result of the stretching protocols. This was not the case in the current study; those who started with lower initial ROM increased or decreased just as much as those who started with a higher ROM.

Subjects were all physically active individuals who exercised on a regular basis, results may have been different in a sedentary or less active population. Subjects were all young and healthy; there may be different results in an older population as well. Future research may want to investigate the effect that exercise itself has as a mechanism to increase ROM with or without involving a stretching protocol.

Limitations

This study had limitations that may have contributed to a lack of significant findings. First, methods described by Leighton (1966) stated the use of three measurement trials and to record the highest value of ROM, in the current study the researcher averaged the values instead much like Williford et al. (1986) who also used a Leighton Flexometer. If the highest value had been recorded there may have been a significant difference from baseline to post-test between groups. In this study an average measure was calculated and individual trials were not recorded.

Second, the inclusion of a warm up, as mentioned before, may have affected the ROM values. It has been noted that even a five minute warm up has an effect on increasing ROM so that possibly the additional 30 minutes had a diminished effect because ROM was already influenced by the warm up. It has been suggested that five minutes is significant to increase ROM and that this time is sufficient enough to warm to muscles causing them to respond to length changes (Williford et al., 1986). If no warm up had been included, significant findings may have been present. Williford and colleagues (1986) also indicated that SS performed slowly it is most likely safe if no warm up is present; which is true in regards to the baseline and post-test measurements.

Conclusion

Based on the results of this study, the following conclusions were made:

1. Thirty minutes of exercise was sufficient to increase ROM in a physically active population of college age men and women.
2. For increasing hip ROM, it is unclear which method of stretching is the most effective.

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APPENDICES

APPENDIX A – DATA SHEET

APPENDIX A

CONSENT TO PARTICIPATE IN RESEARCH

Efficacy of a Single Session of Static Stretching and Proprioceptive Neuromuscular Facilitation Stretching on Hip Range of Motion after Exercise

You are invited to participate in a research study conducted by Hannah Vacey B.S., from the Kinesiology and Sports Studies Department at Eastern Illinois University. Your participation in this study is entirely voluntary. Please ask questions about anything you do not understand, before deciding whether or not to participate.

The purpose of this project is to compare three stretching protocols and their effect on hip range of motion after an exercise session.

PROCEDURES

If you volunteer to participate in this study, you will be asked to:

1. Complete a pre-participation screening including a measurement of weight and information about your exercise history.
2. You will be randomly assigned to either a control group or one of two stretching groups. Testing will take approximately one hour. You will be asked to perform a short warm up, a thirty minute exercise session followed by the stretching procedure assigned to you and have two measurements of hip flexibility taken.

POTENTIAL RISKS AND DISCOMFORTS

You may experience some muscle soreness as a result of this study but it should be minimal and will dissipate within a day. You may experience some mild discomfort as a result of the stretch, but only during the stretching portion of the procedure. The researcher will perform all stretches and measurement by physically touching the legs and possibly hips.
Eastern Illinois University is not able to offer financial compensation nor to absorb the costs of medical treatment should you be injured as a result of participating in this research.

POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

You may gain knowledge of stretching protocols and are welcome to ask questions at any time. You may use your participation in this study as a future reference in your professional career. You will be told your results if you wish to know after all measurements have been taken. The benefits to society include a greater knowledge base on flexibility and stretching protocols and information about the effect of exercise on flexibility.

CONFIDENTIALITY
Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by keeping your file stored in a computer file with only Hannah Vacey having the password, and by coding all data files that are used for statistical analysis with a subject number rather than with your name. Reports written about this study will not contain any information about individuals or any information from which you can be identified as a participant. The reports will not contain your name. Results will be reported as group averages rather than individual scores.

PARTICIPATION AND WITHDRAWAL
Participation in this research study is voluntary and not a requirement or a condition for being the recipient of benefits or services from Eastern Illinois University or any other organization sponsoring the research project. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind or loss of benefits or services to which you are otherwise entitled. There is no penalty if you withdraw from the study and you will not lose any benefits to which you are otherwise entitled.

IDENTIFICATION OF INVESTIGATORS
If you have any questions or concerns about this research, please contact:
Primary Investigator
Hannah Vacey B.S.
hjvacey@eiu.edu
(708) 253-7960
Faculty Adviser
Dr. Mark Kattenbraker
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(271) 581-8549

RIGHTS OF RESEARCH SUBJECTS
If you have any questions or concerns about the treatment of human participants in this study, you may call or write:

Institutional Review Board
Telephone: (217) 581-8576
Eastern Illinois University
600 Lincoln Ave. Charleston, IL 61920
E-mail: eiuirb@www.eiu.edu

You will be given the opportunity to discuss any questions about your rights as a research subject with a member of the IRB. The IRB is an independent committee composed of members of the University community, as well as lay members of the community not connected with EIU. The IRB has reviewed and approved this study.

I voluntarily agree to participate in this study. I understand that I am free to withdraw my consent and discontinue my participation at any time. I have been given a copy of this form.

X____
Printed Name of Participant

X____
Signature of Participant Date

I, the undersigned, have defined and fully explained the investigation to the above subject.

____
Signature of Investigator Date

APPENDIX B – DATA SHEET

APPENDIX B

Subject Name:______________________________ Email Address: ____________________________

Age:____________ Gender:____________

In the last 3 months:

___I never engage in aerobic exercise.

___I have engaged in aerobic exercise 0-1 days a week

___I have engaged in aerobic exercise 2-3 days a week

___I have engaged in aerobic exercise 4-7 days a week

In the last 3 months:

___I never engage in aerobic exercise.

___My aerobic exercise lasts 10-30 minutes per session

___My aerobic exercise lasts 30-60 minutes per session

___My aerobic exercise lasts 60-90 minutes per session or greater

Resistance training program:

___I perform strength activities never

___I perform strength activities 0-1 days a week

___I perform strength activities 2-3 days a week

___I perform strength activities 4-7 days a week

Flexibility training program:

___I perform flexibility exercises never

___I perform flexibility exercises 0-1 days a week

___I perform flexibility exercises 2-3 days a week

___I perform flexibility exercises 4-7 days a week

FOR RESEARCHER USE ONLY:

Subject #: ____________

Dominant Leg: ____________

Height: ____________

Weight: ____________

Group: C SS PNF

Treadmill Speed: ____________

RPE:____________

Baseline ROM in degrees: ____________

Final ROM in degrees: ____________

Change in ROM: ____________